lems that can and must be studied quantitatively. The solution of these problems will be not only of the greatest importance to abstract science and to industry, but will take first rank in giving an insight into the fundamental processes in plant and animal life, which involve both chemical and physical phenomena in homogeneous and heterogeneous systems.

These problems will, in my opinion and that of some of my physical chemical colleagues, be solved most easily by organic chemists, and not by physical chemists. The worker who would do great service to this branch of the science must have *as the great essential* such a broad and deep knowledge of organic chemistry that he can recognize wrong interpretations of reaction mechanisms almost by *intuition:* he must not make wrong postulations regarding reactions as Ostwald did in the *theory of indicators* and in the *catalysis of amides,* and as Euler did in the *saponification of esters,* mistakes which were corrected by *organic chemists.* Then he must turn to his physical chemistry and learn *three things well*—the mass law, thermodynamics and electrochemistry; even then he must constantly advise with some well-trained *real* physical chemist, and with some mathematician, who can to some extent understand the problems.

No man can do *trustworthy* work in physico-organic chemistry with half-way preparation, but the chemist who is well equipped will render great service to the science.

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December 30, 1908

BACTERIOLOGY AS A NON-TECHNICAL COURSE FOR PUBLIC SCHOOLS[1]

BACTERIOLOGY, a biological science as distinct from a useful art, has hardly received any material recognition as yet in this country. The writer would advocate the academic study of certain of its phases as illustrating the general bases of life, as a mental training, and as furnishing a field for thought.

Again realizing that sociology, in ultimate analysis, is strictly dependent upon and limited by biological laws, sociological teaching which neglects the biology and physiology of the individual neglects the study of its primal units. Hence the value of, even necessity for, the elementary biological training of the prospective sociologist. But sociology is more than the study of certain units in multiple. It is the study of the interrelations of these units. Therefore, the study of the anatomy and physiology of a single example of man (or for convenience and by analogy of the frog or the plant) furnishes no actual laboratory biological study analogous to the study of the interrelations of man in the world. Bacteriology supplies this missing link, for bacteriology deals hardly at all with the individual—almost wholly with aggregations of individuals. Symbiosis, antagonism—the effect of overcrowding, the survival of the fittest—coordination of partial efforts of different cooperating species to produce a sum total result—all these phases of sociology, chosen from many more for this address at random, can be illustrated in a bacteriological course—and with materials directly under control, subject to experimental variation and, from the rapidity of bacterial development, without waste of time.

Finally, beyond these purely scholastic views lies a practical value of bacteriology as a general study, especially for women, in that it furnishes an armamentarium in dealing with certain every-day problems of household life which come into play during at least one half of the conscious waking life of man and almost the whole of the conscious waking life of the alma mater of the family—the housekeeper and actual food provider, as the wife and mother must always be in nine tenths of the population. The writer will discuss the third of these phases, *i. e.,* bacteriology for its

[1] Presented at the Baltimore meeting of the Society of American Bacteriologists, December 31, 1908.

hygienic teachings, and especially for its technique, in more detail but still without any attempt to exhaust the subject, as a suggestion to those more actively engaged in pure teaching than himself.

Bacteriology for the General Student.—Huxley somewhere has said that if it were inevitable that every human being must at some time in his life play a game of chess against an expert, the stakes being his continued existence, then the parent or state might well be indicted for criminal negligence if no knowledge of the great game were taught. A better parable concerning the teaching of bacteriology to the general citizen could not well be offered. Surely if it is worth while for children to spend years in studying music, geography, the higher mathematics, the dead languages and many other subjects not strictly necessary to existence—most of which are never used by the great mass of the public, all of which, except in their simplest forms are quickly forgotten by the average citizen—all of which must be entirely relearned by the occasional individual who intends to become an expert in them—why should not children be taught the fundamentals of a subject of daily importance to them throughout the rest of their lives? The present teaching of physiology in the public schools is really academic, for so much of it as may have any slight reflex of physiological truth is but dimly understood by either the teacher or the child, and is at best quickly confused and forgotten. Moreover, the complicated nature of the whole teaching in modern physiology is such that even the physician can use little of it in practise and draws no deductions from it without the most exhaustive tests of his deductions before daring to apply them. What then can be the value of the deductions for leading a hygienic life which the child may draw from public-school physiology, when the fact is that he generally leaves school at fourteen or sixteen, *i. e.,* before his mental grasp is well developed? The best known investigators of the relatively simple questions of dietetics swing from one extreme to the other notwithstanding long years of intimate anatomical and physiological study in the most highly equipped laboratories. Within five years, minimum feeding; maximum feeding; complete mastication; bolting the food whole; a selected diet carefully weighed, measured and calculated; and free feeding at the dictates of the appetite have all been advocated by our "highest authorities." What can the study of a mere diagram of the intestinal tract and the learning of the names of different portions of the gut do in enabling the future citizen to decide how or what to eat? Consider the case of a native South Sea Islander if the study of a railway map of the Twentieth Century Limited, printed in a foreign language, and demonstrated by a fellow savage, be the sole available source of knowledge on the subject of railway transportation on which he is to decide what produce to ship and how and when to ship it?

Bacteriology as compared with physiology is a relatively simple matter. Its fundamentals are fixed; so far as deductions of value to the ordinary citizen are concerned, any one can make them who knows the merest rudiments. Its basic elements do not require for demonstration the elaborate apparatus and animal experimentation of the physiologist—the elements can be worked out in the kitchen—as the writer worked them out years ago. Imagine the whole population having even so much real first-hand experimental knowledge of bacteriology as a medical student at the end of his first three weeks' bacterial training. At least the principles of the transfer of unseen infection on hands and utensils would be known and the general rules as to distribution of bacteria, sterilization of foods, utensils, etc. Above all, the personal defense by the individual upon which must always rest the ultimate escape from infectious diseases would be understood and its simple methods learned. In the great campaigns now waging against tuberculosis and other infectious diseases in mankind, the education of the people is the great cry. Unfortunately this education has so far consisted chiefly in teaching the etiology, pathology, distribution and economics of disease—mere formularies to the average mind, like the statistics concerning alcohol

and intemperance in another field. The "education" ought to consist in teaching the individual how and what to *do, i. e.,* the simple bacteriological knowledge and simple bacteriological technique necessary to avoid "the swallowing, by one individual, of the discharges of other individuals." This knowledge, taught as the chief end of a simple bacteriological course, could be conveyed in lessons and class-room demonstrations, not of diagrams, but of real living bacteria, without involving the opposition engendered by anatomical or physiological demonstrations on living animals which alone will ever make physiology anything but a formula to the lay (or to any other) mind. That it should be taught in the elementary schools, and especially to the girls, is made clear by the two facts that the majority of children (about 80 per cent.) leave school before the high school[2] is reached, and that upon the girls as housekeepers and mothers must the family defense depend, as well as, by precept and example, the proper training of the children in the personal defense against infection.

Community defense against infection as contrasted with family and personal defense is a matter for the public health official, and the lack of this distinction between what is personal or family and what is public health seems to be a great stumbling block over which many earnest souls have fallen more than once. Public health must always deal largely with the prevention of the infection of public utilities with human discharges—especially infected human discharges; while family and personal defense is a matter (primarily) for the mother. When it is remembered that the great mass of all the infectious diseases of the country, especially in children, are necessarily handled and nursed, not in hospitals by trained nurses but inevitably and necessarily by mothers, so that the greatest single factor in the spread of infection from the recognized case, at the present time, outside of public utilities, is again inevitably and necessarily the mother, then the training of the prospective mother in simple bacteriologic technique, at first apparently a wild dream, becomes a most practical and serious problem. Educators in bacteriology should most earnestly ask themselves if the invaluable information concerning the existence, distribution, and above all the avoidance, of bacterial infection which to them is a mere commonplace should not be widely distributed amongst the people. Are the bacteriologists of the country doing their whole duty in confining their teaching to students of the arts of medicine, public health, industry and agriculture? Is not the time ripe for a propaganda for the teaching of bacteriology to the masses? The trained bacteriologist may pass unscathed through fifty epidemics of the ordinary infectious diseases—not because of anatomical or physiological training, not even because of epidemiological knowledge—but wholly because he understands the simple elements of bacterial aseptic technique and follows them logically and consistently. Surely it is the duty of the bacteriologist to pass on the simple technique of bacteriological asepsis at least to the people at large. It is not for the physician to do it—except at the bedside and for the individual case. It is for the bacteriological teacher to enforce personal defense against infection amongst the well before the bedside is reached—to furnish the groundwork upon which the physician may build on occasion. Such courses should be given in the public schools in such grades as to reach the children between eight and sixteen years old; these courses should consist in their simplest form of demonstrations, through use of agar or gelatin plates, of the existence, and distribution of bacteria in air, water, milk, dust, feces, etc., and especially on hands: extending somewhat in scope and in individual experimental work as the grades are ascended. Microscopes would not be essential and the necessary apparatus and media could be furnished at a very low cost.

In the high schools, gradual advance in the detail of experiments should be arranged with

[2] It seems unlikely that more than 20 per cent. of the population receives high school education; or more than 1 per cent. a university education.

quantitative experiments, possibly some species work and the microscope should be introduced.

In the university academic and especially in university sociologic courses the most intricate problems of interrelations of bacteria to each other as illustrating similar interrelations in human life might be conducted. Of course all this presupposes a bacteriological training of the teachers of the public and high schools.

For the present, the education of the mothers of the present might be attained, as suggested by Dr. Norman MacL. Harris, through lectures and simple "courses" given before mothers, in connection with settlement work or in the mothers' meetings sometimes held in connection with the graded schools: women's clubs might secure teachers ready to give short courses in elementary laboratory work. Perhaps "correspondence courses" in the great journals devoted to women might, under proper supervision, stimulate many mothers to do a little elementary bacteriology at home. However done, it is the writer's belief that until such teaching is done—and done by methods involving not merely lectures or demonstrations but personal experiments by the mothers (present and prospective) themselves, the methods of personal defense against infection will never so take their proper place as to be real factors in the suppression of disease. Only when the "cleanliness" of fresh collars and cuffs and nicely brushed hair, etc., has added to it the real cleanliness of hands free from the discharges of the toilet room will personal cleanliness mean anything in relation to infection.

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TEACHING BY THE LECTURE SYSTEM

At an open meeting held a short time ago by the Case School chapter of the society of Sigma Xi, for the discussion of subjects of special interest to the members of the instructing staff at the Case School of Applied Science the lecture system was discussed. The different ideas presented seemed to suggest that a paper on this subject might be of some interest and possible benefit. I shall not discuss the efficiency of the lecture system as compared with other systems of teaching a science, since there can be little doubt but that under existing conditions this method if properly carried out is by far the best one for most sciences; but I shall treat of the various means of carrying it out and try to indicate those which seem best suited to attain the highest efficiency.

It is not the purpose of this paper to give in detail a full treatment of the different points to be considered in presenting a science course by the lecture system, but rather to collect a few facts and ideas which may, in this way, come to some who possibly have not been placed in an environment which would demonstrate the importance of the matter, and who have therefore not put as much thought on this particular question as efficient teaching would demand. A science should be presented in such a manner as will make its particular group of natural phenomena understood with the least possible expenditure of mental exertion and time on the part of the student. The presenting of a science in this manner should be the aim of the science teacher. Further, the teacher should strive so to correlate facts and suggestion that the phenomena and their explanation should be the most easily remembered.

In most of our schools, existing conditions make the lecture system by far the best for presenting a science to a class of students. This fact is more especially true in a largely experimental science, such as in chemistry or in physics. As the teaching of chemistry has been the vocation of the writer, what follows will probably apply more to the teaching of chemistry than to the teaching of any other science. The question then resolves itself into: what is the best method for conducting a lecture course so that its qualities shall be clearness, comprehensiveness, individual completeness and individual broadness? It is not alone sufficient to give a man knowledge. The subject must be presented to him in such a manner as to interest him sufficiently to make